NIST CENTENNIAL 1901-2001

UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
Gaithersburg, Maryland 20899-

REPORT OF SPECIAL TEST

OF
AIR SPEED INSTRUMENTATION

April, 2001

Optical Scientific, Inc., Optical Flow Sensor System
Serial Number 0900002

submitted by

Optical Scientific, Inc.
205 Perry Parkway
Gaithersburg, MD 20877

(Reference: Purchase Order Number 510140 dated April 4, 2001)

The calibration of the above mentioned anemometer was performed in the 1.5-m by 2.1-m rectangular test section NIST Dual Test Section Wind Tunnel.[1] In this tunnel, the air speed is measured by a substitution method, where the NIST laboratory standard Pitot-static tube indicates the air speed that would be present in the absence of the anemometer under test and its support.

The test was conducted at a location 7-m downstream from the entrance area of the wind tunnel test section. This position is not the typical location where NIST air speed calibration test are conducted, and a velocity-position test was performed to validate the positioning of the NIST laboratory standard Pitot-static tube at this location. A relationship was established between the normal measurement location and the position used for this test. During the test, the air stagnation temperature, stagnation pressure and the relative humidity were measured in the tunnel settling-chamber. The air temperature, barometric pressure, and relative humidity were measured at the location where the NIST laboratory standard Pitot-static tube was positioned.

To ascertain the reproducibility[2] of the anemometer under test, two calibration cycles were done separated by a tunnel shutdown. During each calibration cycle, each air speed was measured five

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[1] N. E. Mease, W. G. Cleveland, Jr., G. E. Mattingly, and J. M. Hall, "Airspeed Calibrations at the National Institute of Standards and Technology," Proceedings of the 1992 Measurement Science Conference, Anaheim, CA 1992.

2 Closeness of the agreement between the results of measurements of the same measurand carried out under changed conditions of measurement. Defined in the ISO, "International Vocabulary of Basic and General Terms in Metrology, 2nd Ed.," International Organization of Standardization, Geneva, Switzerland, 1993. (This document is abbreviated VIM.)

times to ascertain the repeatability[3] of the anemometer under test.

Tables 1 and 2, and Figure 2 show the expanded uncertainty values for the NIST air speed calibration facilities. The data listed in the remaining tables were calculated from the means of the 10 measurements at each speed. The expanded uncertainty of the measured values for the anemometer under test, U , is given by[4]

$$U = k\sqrt{u_A^2 + u_B^2}$$

where k is the coverage factor (taken to be 2), u_A is the standard deviation of the ten measurements at each air speed, and u_B is one half the uncertainty of the NIST facility at the given speed (see Tables 1 and 2, and in Figure 2).

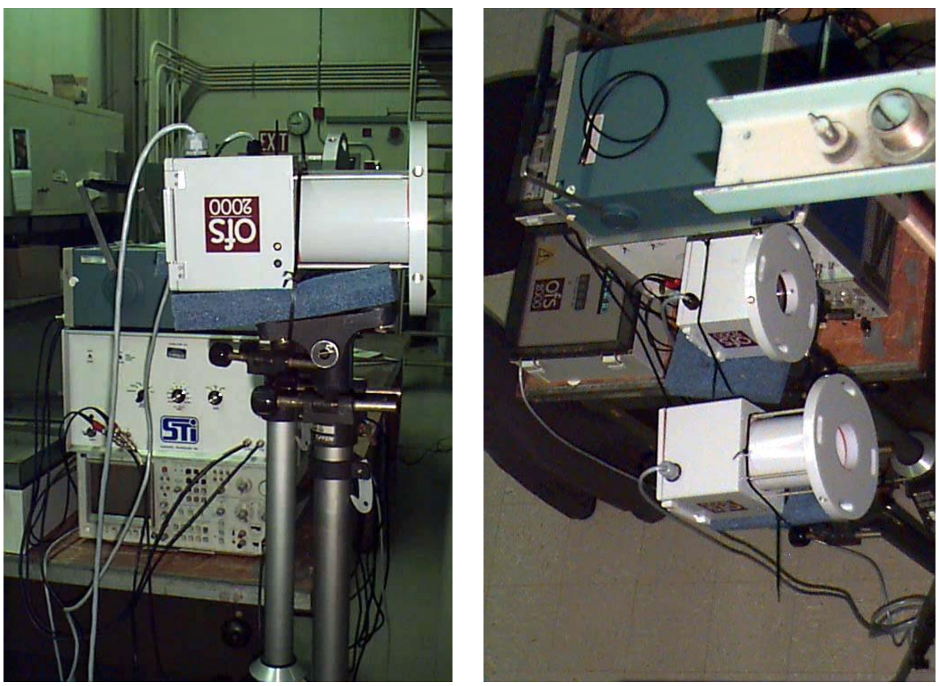

Figure 1. Images of the Optical Scientific, Inc., Optical Flow Sensor System. *Left* – side view of transmitting optics as installed in the NIST Dual Test Section Wind Tunnel. Right – top view of the transmitting optics as installed in the NIST Dual Test Section Wind Tunnel.

The anemometer under test (see Figure 1) uses optical scintillation technology to measure flow of

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3 Closeness of the agreement between the results of successive measurements of the same measurand carried out under the same conditions of measurement. Defined in the ISO VIM.[2]

4 B. N. Taylor and C. E. Kuyatt, "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results," NIST Technical Note 1297, National Institute of Standards and Technology, January 1993.

gases. The technique measures air velocity by temporal correlation – the time-difference between optical scintillation signals detected by the receiver aligned orthogonal to the flow direction. The method is non-intrusive and measures the average flow across an optical path. The optical sensors were placed outside the tunnel, perpendicular to the flow and roughly 4-m apart. The width of the tunnel at this location is 2.1-m. The transmitter emitted a visible beam of light – generated by a light emitting diode with a wavelength of 680 nm – which entered the Dual Test-section Wind Tunnel through one of its Plexiglas windows.

The anemometer under test is designed to make measurements in turbulent flows. In order to increase turbulence levels in the NIST wind tunnel, hot-air guns were installed in the test-section at a position 2-m upstream from the sensing area. The hot-air guns introduced heat into the tunnel perpendicular to the flow direction. This lead to increased density fluctuations in the test section.

The NIST laboratory standard Pitot-static tube was placed in the tunnel at a position 0.13-m below the sensing area of the instrument under test, at a position and 0.38-m away from the tunnel wall. Temperature and humidity sensors were placed in the area where the NIST laboratory standard Pitot-static tube made its measurements, and were used to calculate the air velocity at this position.

Results for the instrument are given beginning with Table 3.

For the Director,
National Institute of Standards and Technology

(Signed by Dr. Espina)

Dr. Pedro I. Espina
Leader, Fluid Flow Group
Process Measurements Division
Chemical Science and Technology Laboratory

Air Speed, m/s	Uncertainty, (%)	Air Speed, fpm
0.2	3.00	40
0.5	1.20	100
1.0	0.60	200
5.0	0.12	1000
10.0	0.06	2000

Table 1. Expanded Uncertainty of the NIST Low Velocity Airflow Facility

Air Speed, m/s	Uncertainty, %	Air Speed, fpm
3	0.60	600
5	0.45	1000
10	0.31	2000
15 - 75	0.28	3000 - 15000

Table 2. Expanded Uncertainty of the NIST Dual Test-Section Wind Tunnels

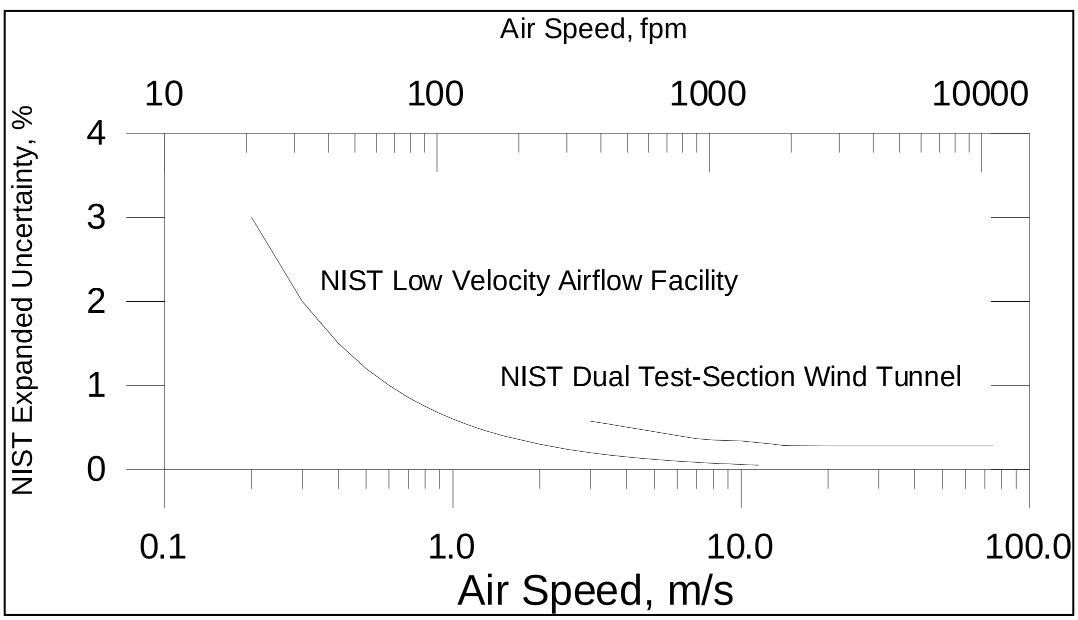

Figure 2. Graph of NIST Expanded Uncertainties - all facilities

NIST Air Speed, m/s	Instrument Output, m/s	Stagnation Temperature, K	Stagnation Pressure, kPa	Relative Humidity, (%)	Expanded Uncertainty, m/s	Expanded Uncertainty, (%)
1.59	1.63	297.59	101.92	40.4	0.12	7.73
2.58	2.75	297.54	101.87	40.6	0.10	3.86
4.94	5.05	297.55	101.80	40.7	0.14	2.84
7.59	7.93	297.56	101.73	40.8	0.07	0.96
9.75	9.70	297.58	101.68	40.9	0.07	0.72
14.8	15.7	297.82	101.60	40.7	0.17	1.16
19.7	20.0	298.23	101.51	40.2	0.15	0.80
24.5	24.6	298.89	101.44	39.1	0.12	0.51
29.0	29.3	299.84	101.33	37.3	0.22	0.77
35.0	35.6	301.44	101.21	34.5	0.63	1.80
40.0	41.6	303.46	101.10	31.3	0.33	0.82

Table 3. Optical Scientific, Inc., Optical Flow Sensor System, Serial Number 0900002 (in the NIST Dual Test-Section Wind Tunnel)

Note 1: Each value of air speed represents the average of 10 readings.

Note 2: The measurement of the Optical Flow Sensor is not affected by temperature, pressure, and relative humidity, therefore no correction has been applied to the test instrument output.

2008 update: OSi's address is now – 2 Metropolitan Ct., Suite 6, Gaithersburg, MD 20878.